Evolutionary split up without geographic barriers

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A fundamental question in evolutionary research is: is a geographic barrier dividing the original population into two genetically separated populations required for the origin of new species? Or is so-called sympatric speciation also possible - the evolutionary divergence of a population within the same geographical area? Only few examples of sympatric speciation are known worldwide, and even these are not without controversy. Evolutionary biologists in Konstanz now have completed the most extensive study of sympatric speciation so far. They used around 20,000 characteristics of 450 fish to document the parallel evolution of cichlid fish in two crater lakes, Apoyo and Xiloá, in Nicaragua. The research carried out by the team of biologists around Professor Axel Meyer and Dr Andreas Kautt found conclusive evidence for possible evolutionary mechanisms of sympatric speciation. At the same time, the researchers underpinned the empirical evidence that had resulted from Axel Meyer's previous study on the sympatric speciation of these cichlids, published in 2006 in the scientific journal *Nature*. The current research findings were published in *PLOS Genetics* on 30 June 2016.

The cichlid fish in the volcanic crater lakes Apoyo und Xiloá in Nicaragua are one of the extremely rare examples of sympatric speciation. In only approximately 800 generations - a period of around 1,000 to 1,500 years - the fish population here has evolved into four to five different species, although the fish had lived in the same lake during all that time. Evolutionary biologist Axel Meyer had already described this astonishing evolutionary phenomenon in 2006, in the scientific

journal Nature. Together with Andreas Kautt, he has now decoded the genetic family tree of the fish populations in detail.

"Our data point to a second wave of colonisation immediately before the separation into two species took place," explains Andreas Kautt. A second group of the same cichlid species reached the crater lake. The biologists assume that this second colonisation renewed the genetic pool of the cichlids and tipped the scales for the separation process.

Three models for sympatric and alleged sympatric speciation are known in evolutionary research. The first model, the most "pure form" of sympatric speciation, describes the development of two species out of a joint population. In the second model, a species colonises a habitat in two or more waves, before they separate into two species. According to this scenario, a swarm is formed through several population waves of the same ancestry - entailing a freshening up of the genetic pool - before sympatric speciation takes place. "Our data indicate that this is the type of speciation that occurred in the crater lakes Apoyo und Xiloá. The second wave of colonisation was integrated into the genetic pool of the crater lake population before the evolutionary split up. The diverging development of the two species took place without geographic barriers," Andreas Kautt explains.

The third model, which is very hard to distinguish and critics often use as a reason for objection, describes only alleged sympatric speciation. This scenario is also based on a second population wave. However, it assumes that the first population of the crater lake had already developed further, before the second population wave arrived. When the two swarms from the same ancestry met, they had already been different species. This means that it would not be a genuine sympatric speciation, as geographic barriers played a role at the time of the divergence. The evolutionary biologist from Konstanz, however, could rule out this third scenario: the genetic family trees of the fish show that the separation

into two species took place after the second population wave. This means that the geneticists have provided the empirical evidence for sympatric speciation in the Nicaraguan crater lakes Apoyo and Xiloá.

The research project was carried out in the context of Axel Meyer's ERC Advanced Grant "Comparative genomics of parallel evolution in repeated adaptive radiations". The European Research Council had awarded Axel Meyer this renowned science award in 2011 to study parallel evolution. Research at the Nicaraguan crater lakes will be intensified in the next few years. Among other things, the evolutionary biologists from Konstanz have planned to completely sequence the genomes of the fish populations.

More information: Andreas F. Kautt et al. Multispecies Outcomes of Sympatric Speciation after Admixture with the Source Population in Two Radiations of Nicaraguan Crater Lake Cichlids, *PLOS Genetics* (2016). DOI: 10.1371/journal.pgen.1006157

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